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An Electronic Device for Communication in Developmentally Delayed Children

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ABSTRACT

This paper discusses problems encountered in the education of non-verbal children with developmental delays. There is extensive review of the literature on training in communication skills, and on the use of electronic aids to communication. The paper is specifically concerned with a synthetic speech device which provides the words "yes" and "no". The paper concludes with a full protocol for the use of such devices.

RÉSUMÉ

Le présent mémoire porte sur les difficultés éprouvées au niveau de l'instruction d'enfants non verbaux atteints d'un retard de développement. On y décrit de façon assez approfondie la documentation qui existe sur l'apprentissage d'aptitudes à communiquer et sur l'utilisation d'aides électroniques à la communication. Ce mémoire porte tout particulièrement sur un dispositif de synthèse de la parole qui répond par "oui" et "non". En conclusion, on présente un protocole complet pour l'utilisation de dispositifs de ce genre.

AN ELECTRONIC DEVICE FOR COMMUNICATION IN DEVELOPMENTALLY DELAYED CHILDREN

K.B. Hranchuk, J.R. Charbonneau, and J. Ehrenworth*

Severe deficits in the ability to utilize effective forms of communication behaviour in people continue to challenge clinicians and researchers alike. To varying degrees, the ability to communicate with one's environment influences an individual's biological as well as psychological development. An effective system to indicate needs as well as to respond to environmental demands is paramount to virtually all levels of human development. As such, the relative degree of deficit in communication skills will have a major influence on a person's overall development. It is not necessary to belabour the point that the behavioural repertoires of equivalently aged children with widely disparate communication deficits (e.g., receptive vs. expressive deficits) will be dramatically different.

The procedure which follows is an attempt to systematically research a method for increasing the capacity of severely physically and developmentally delayed children to communicate. An electronic Yes-No communicator utilizing synthesized speech will be empirically evaluated with four subjects within a multiple baseline across subjects paradigm (1).

Historically, remedial programs and associated research have emphasized oral communication skills training (2-8). These interventions have demonstrated different levels of success with severely handicapped children (2), the developmentally delayed (6, 7, 9), psychotic children (4), autistic children (10), mute psychotic adults (11), and disadvantaged children (12). The importance of continued research and associated applications of empirically based procedures in oral language training cannot be overemphasized. However, oral communication techniques have not proven to be successful with the non-vocal severely handicapped (13) and/or severely developmentally delayed persons (14-16). This state of affairs has led to the investigation of non-vocal communication techniques utilizing several different modalities. One area of prime emphasis in the development of non-vocal communication has been the use of symbols and associated systems (see ref. 17 for a review). Some non-vocal methods used for communication include American Sign Language (18), gestures (19), symbols representing words (15, 20), Blissymbolics (21), and iconic stimuli (22). For a more detailed description of the variety of methods of non-vocal communication see Lloyd and Karlan (17).

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The responses required to facilitate the use of non-vocal communication methods include hand-formed signs (23), pointing with a finger or an assistive pointing device (14), or activating a button or switch (24). The most common method of presenting non-vocal communicative stimuli is the communication board (13, 25). Receivers of non-vocal communication require varying degrees of sophistication ranging from the ability to interpret signs such as those used in American Sign Language and Blissymbolics, to translating iconic stimuli, to simply perceiving artificial language such as synthesized sound.

The use of electronic and non-electronic communication boards to augment communication in non-vocal persons is widespread (26). However, perusal of the research literature reveals that in the majority of cases reports of their use and effectiveness are descriptive and anecdotal. Vanderheiden and co-workers (25, 27-29) have described a wide variety of communication boards utilizing numerous symbolic systems. More recently, similar descriptive reports of such communication devices along with anecdotal reports of their effectiveness have also appeared in the literature (30-32). For example, Silverman (30) spends 48 pages in his book (pp. 113-161), describing "Nonelectronic Gestural-Assisted Communication Systems" and "Electronic Gestural-Assisted Communication Systems" without reference to how to train people in their use. In a later chapter (pp. 207-220) in the same book entitled "Intervention Strategies for Nonspeech Communication Modes," Silverman's only reference to training human subjects is Carrier and Peak's (33) non-SLIP Program which teaches the concept of symbols to mentally retarded persons. That program is based on Premack and Premack's (34, 35) earlier work with primates.

Recently, Hurlbut et al. (13), recognizing the lack of experimental research using symbol systems and non-electronic communication boards, used an alternating treatment design (36) to assess acquisition, maintenance, stimulus and response generalization, and spontaneous usage of Blissymbols and an iconic picture system with severely handicapped non-vocal adolescents. The results of the study indicated that the experimental subjects required approximately four times as many training trials to learn Blissymbols as iconic pictures. In addition, the results revealed that a higher percentage of iconic pictures were maintained, generalized, and used in an analyses of spontaneous usage. Recognizing the limitations of iconic pictures, Hurlbut et al. (13) do suggest that such stimuli may be the most efficacious in strengthening early communication skills in handicapped persons. In an earlier investigation Reid and Hurlbut (14) experimentally analyzed the utility of communication boards with non-vocal physically disabled retarded adults. The results of their study indicated that consequent to coordination training the subjects, using either a hand or

prosthetic head pointer, learned to accurately point to pictures and descriptor words of preferred leisure activities in response to verbal requests. In a final phase of their study Hurlbut et al. demonstrated that their subjects' ability to use the communication boards generalized to people who previously could not communicate with the subjects.

An example of research conducted with an electronic communication aid was performed by Hill et al. (37). The study involved a six-year-old athetoid cerebral palsied female child. The apparatus consisted of a response panel with six keys which allowed the child to make responses that registered on a keyboard. The experimenters were analyzing the child's recognition vocabulory, verbal comprehension, and ability to discriminate color, size, and form. No data were presented and the results of the experiment were presented anecdotally in the following fashion:

> "In summary, S adapted to the use of the response panel in responding to vocabulary problem, in indicating her comprehension of material read to her and in solving match from sample problems along forms, size, and color dimensions". (ref. 37, p. 701).

An extension of the keyboard using an IBM typewriter was presented in the same paper (37); however, no data on the training program were provided. Yet the authors state that their training procedure was quite successful. This example is one of many that use anecdotal reports of successful applications of electronic communication aids for non-vocal subjects.

As mentioned earlier, the purpose of the present research project is to experimentally analyze the effectiveness of an electronic Yes-No communicator with severely physically and developmentally delayed children. Before the rationale for the research and its associated procedure can be presented, a discussion of electronic communication aids is necessary.

An extensive literature review of electronic communication aids over the past 10 years revealed some startling results. Of 44 articles and books directly related to electronic assistive communication aids, none involved acceptable experimental analyses of the devices (a list of references is available from the senior author). It can be stated with a high degree of confidence that electronic technology has far outstripped applied research in the area. Technical descriptions of the devices are numerous and very informative to the reader (29). However, experimental analyses of training strategies, types of switches used to activate visual or auditory information, and different modes of such information or functional usage of

the devices by the non-vocal communication disordered person have not been performed. Anecdotal reports of the effectiveness of such devices abound in the literature. For example, Fairweather et al. (32), in a book entitled "Communication Systems for Severely Handicapped Persons," describe a wide array of switches and communication boards, and provide information about where to obtain such devices. However, no references are made to experimental studies verifying the relative effectiveness of different switches or boards, or which populations may benefit from the device.

The types of electronic communication aids developed to this point are wide and varied (see refs. 25 and 30). Silverman (30) describes 15 types of switches ranging from push switches to light-controlled switches that are used to activate numerous electronic communication devices or communication boards. He then describes 11 electronic displays or communication boards. The displays range from Morse code to speech synthesizers with the only reference to the effectiveness of the electronic aids for increasing communication skills being anecdotal.

In view of the above, several important points should be considered. The rapid technological developments of electronic communication aids for non-vocal handicapped persons is very important. In recent years physical scientists such as biomedical engineers have become integrally involved in developing electronic communication aids (17). Their productivity and creativity in developing these devices have been exceptional as indicated by the variety of devices which are presently commercially available. In hand with the large number of anecdotally reported successful utilizations of the technology it would appear that future developments in the area will continue. It is therefore very important that significant applied research assessing numerous variables associated with electronic communication aids be performed. Of prime importance is the experimental verification that such electronic devices can be systematically used to develop different forms of functional communication skills in non-vocal subjects. Initial evaluations of training subjects to activate switches and to use that skill in a learning paradigm are also important. In addition, experimental evaluations of response and stimulus generalization as well as maintenance of acquired skills over time are necessary.

The importance of experimentally analyzing the above factors cannot be overstated. Early intervention designed to provide non-vocal persons with a means of communication is crucial. The establishment of such skills in young physically impaired children will establish a baseline upon which further skill development can be generated. With advancing technology the sophistication of electronic communication aids will increase. Therefore, teaching young multiply handicapped children to use switches as interfaces

for more and more complicated electronic communication devices (i.e., synthesized speech or communication boards) is an important future consideration. In view of the increasing evidence that teaching non-vocal methods of communication does not necessarily hinder the development of oral communication (see ref. 38), the earlier we establish any mode of communication the better. In addition, although purely hypothetical, it may be the case that continued increases in development delay may be allayed or perhaps decreased due to early non-vocal communication training in young children. Finally, as mentioned above, the difficulty in teaching oral language skills to multiply handicapped individuals continues to be problematic and applied research using electronic communication aids may be a most important future direction for that population. The procedure which follows is an initial attempt to establish some scientific data to support the acquisition of communication in young severely physically and developmentally delayed children using a Yes-No electronic device.

METHOD

Subjects

Subjects are expected to be selected by appropriate members of the team, who will establish their own criteria.

Setting

The following research program will be conducted at John Butler School, a day program for multiply handicapped developmentally delayed children. The program is operated by the Ottawa and District Association for the Mentally Retarded in Ottawa, Ontario. The program can accommodate 32 children and has a staff-student ratio of 4:1 with appropriate support staff, teacher aids, and consultants in speech therapy, occupational therapy, physiotherapy, and behaviour management. The teachers are all well trained in dealing with this population of children and have experience in individual and group programs. At the time of this research project the school was servicing 21 children, with only one child being ambulatory and only one child using one expressive word (her name). All training sessions will be carried out in a 3 m × 3 m room with a one-way mirror and an intercom system.

Trainers

Consequent to consultation with the program supervisor two trainers for the research project were selected. Wherever possible the trainers were matched for experience, training, age, and overall ability as

teachers. On the basis of these criteria one male and one female teacher were chosen. All sessions will be conducted by these teachers, with each being responsible for two children.

Apparatus

The Yes-No communicator, better known as Voice Mate, is intended mainly for the use by non-vocal children. It allows the user to make responses to questions using synthesized speech which approximates that of a human voice. The unit is activated by pressing one of two 2½ in. (6.4 cm) diameter buttons. The buttons require approximately 20-25 g of pressure for activation. The unit may also be operated by connecting two single or one Ability Switch to a 1/8 in. (0.3 cm) miniature phone jack on the main unit. Yes or No responses are available in English or French and can be selected by a switch located in the battery compartment of the unit. Volume can be adjusted by a control on the back of the unit. One 9-V battery provides several thousand responses. The dimensions of the unit are 10 in. × 7 in. × 1½ in. (25.4 cm × 17.8 cm × 3.8 cm) and it weighs 1½ lb (0.6 kg), making it highly portable.

All experimental sessions will be taped using a standard Sony Betamax camera and Sony VCR unit.

The three-dimensional objects used for training and testing include a spoon, cup, toothbrush, and shoe.

Pretreatment Training

Prior to the experimental phases each subject will be trained to push a single switch. This phase will ensure that each subject will be able to activate the switch in a consistent manner consequent to a verbal prompt and to be adapted to the yes and no synthesized speech. The procedure will involve a combination of verbal prompts, graduated physical guidance, responding to either left or right of centre, and random exposure to the synthesized yes or no sound. All sessions will be conducted in the training room at approximately the same time every morning and afternoon until criterion performance is obtained. Sessions will involve 15 min of training performed in the following manner. Prior to beginning training, the trainer will spend 2-3 min socializing with the child via social and physical interactions. Training trials will then begin and will be carried out using the following procedure. Consequent to obtaining eye contact the trainer will instruct the child using a verbal prompt by saying, "**child's name**, push the button". If the child responds within a 30 s interval by depressing the switch and activating the synthesized sound, the trainer will label the response ("**child's name**, good you pushed the button")

and the next trial will begin. No response within the specified time period will result in the trainer repeating the instruction and using physical guidance to assist the child in pushing the switch. The amount of physical guidance required to assist the child in responding will be gradually reduced contingent upon the child's performance over trials. Social reinforcement identical to that used for verbally prompted trials will be used for physically prompted trials. The switch will be placed either 3 in. (7.6 cm) to the left or right of the child's midline on each trial. Placement will be determined in a random fashion with left or right responses never required more than three times in a row and with all left and right positions equally distributed over trials. The yes or no synthesized speech will be activated so that when the switch is to the left of midline the yes occurs and no occurs when the switch is in the right position. Ten consecutive correct responses to only the verbal prompt will be the criterion to learning for each subject.

Baseline

Baseline session will involve requiring the subjects to indicate whether a three-dimensional object was correctly or incorrectly labelled by a trainer. The Yes and No switches will both be present during baseline testing.

The best way to explain a baseline trial is by way of example. Baseline trials will begin as follows, a subject may be presented with a spoon and the trainer will say "**child's name**, is this a spoon?" or "**child's name**, is this a cup?" with correct responses respectively being "Yes" and "No". Four objects will be presented over 16 trials to each child with each object being presented an equal number of times. Of the four presentations per object, two will require a correct yes response and two a correct no response. Order of object presentation and yes or no correct response will be randomized within each 16 trials per session. Sessions will be carried out once per day at approximately the same time in the afternoon. Each trial will be conducted in the following manner. The yes and no switches will be placed 3 in. (7.6 cm) to the left (Yes) and 3 in. (7.6 cm) to the right (No) of the child's midline and within easy pushing distances. The yes-no unit will be placed 5 in. (12.7 cm) behind the switches with the speaker end of the unit facing the child. The trainer, after obtaining eye contact, will present an object to the child and as described above will verbally request a yes or no response from the child. The trainer will record yes, no, or no response data on a recording sheet. No physical prompts, corrective feedback, or social reinforcement will be used during baseline sessions. On occasion the child will receive a small glass of juice after a session. Within sessions, the trainer will periodically priase the children for consistent responding but not contingently upon correct or incorrect response.

Yes-No Training

Consequent to the baseline sessions each child will be involved in Yes-No training within a multiple baseline across subjects design (9), using two independent trainers (see above). The training sessions will last 15 min and be conducted at approximately the same time every morning and will include verbal commands, social, and edible reinforcement for correct response and an error correction procedure. The same method of randomly presenting the objects and questions as that used during baseline will be used during training.

The placement of the yes and no switches will also be identical to that of baseline testing. All training trials will begin in the following manner. The trainer will present an object and label it correctly ("**child's name**, this is a spoon"). The trainer will then pause for 5 s and ask the child for a correct yes or no response by either saying, "**child's name**, is this a spoon?, or "**child's name**, is this a book? A correct response by the child will result in the trainer labelling the response, "Yes, **child's name**, this is a spoon", or "Very good, **child's name**, this is not a book." All correct responses will be followed by social reinforcement and on occasion edible reinforcement (6-8 times per session). An incorrect response will result in the utilization of an error correction procedure. The procedure will include the trainer labelling the error by saying either, "Yes, **child's name**, this **is** a spoon," for a No response, or "No, **child's name**, this is a book not a spoon," for a yes response. That step will be followed by repeating the original question and allowing the child to respond. A correct response will be reinforced and the next trial will commencae. An incorrect response will result in one additional error correction procedure being performed. During this error correction phase the trainer will physically guide the child's hand to activate the correct switch while labelling the correct response. The next trial will then begin. In order to prevent confusion, the object being labelled by the trainer (such as a book in the above example) will never be one of the four objects being trained. As many trials as possible will be performed during each 15 min session.

Probes

Sixteen trial probe sessions identical to those used during baseline will be conducted at approximately the same time every afternoon. The purpose of the probes is to assess the progress of acquisition as a result of the training procedure.

One subject (Subject 1) will also be tested for therapist and setting generalization effects. As discussed above, the mother of Subject 1 will

be involved in probe sessions at home. Prior to the evening meal each day, probe sessions identical to those conducted at school will be performed by the mother.

Response Recording and Reliability

Correct and incorrect responses or no responses within the defined time limits will be recorded during baseline and probe tests. The trainers will record the responses on a data sheet designed for that purpose. All sessions will be videotaped during baseline and probe tests. Forty percent of all sessions will be analyzed for interrater reliability. Raters will be trained in the recording procedure and will be unfamiliar with the purpose of the experiment. Reliability will be calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100.

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